DATA NEEDS (Non-Technological/Non-Environmental)

Establishing Data Standards/Needs	Lack of water supply and quality data needed for long-range energy development and energy-water planning Lack of consistent data bases for water information integration	R&D: Define what types/scale of data are needed for energy/water modeling—frame questions, identify data needed for regional or national energy/water planning (including identification of output parameters, accuracy and precision requirements) (DOE/USGS/other state and federal agencies) R&D: Examine and identify data needs and gaps as a result of defining data needs for energy/water modeling. (USGS, DOE) R&D: Statistical methods for robust monitoring—where/how frequently to monitor for energy-water planning (DOE/EPA/USGS/universities) I: Coordinate quality/quantity monitoring and data collection matching (temporal, areal scales). (USGS, states, DOE)	R&D: Develop a remote sensing/GIS based program for rapid access to the output data for regional and national energy planning.	**GOAL: Integration and centralization of water information into a National Water Information data base**
	Lack of coordinated water data collection – USGS, EPA, FERC, state agencies all collect data but not all in a form that can be easily accessed or used for energy planning	I: Define/deploy standardized data collection framework across fed/state/local entities. I: Evaluate and assess water data needs for energy (DOE/USGS/ other fed agencies).		**GOAL: On-line, integrated information system and databases geared to providing data for regional and national energy/water modeling and planning.**
Enhanced data collection/mapping of impaired and brackish water resources	Lack of data on generation and availability of impaired water at regional level for energy development – produced water, brackish water, reuse water, etc.	R&D: Develop parameters for a national inventory of impaired water resources that may be utilized in/for energy production (DOE/USGS/EPA and others) R&D: Evaluation/analysis/quantification/mapping of non-traditional/produced/brackish /reused waters quantity and quality that could be used for energy development ((WIA/USGS/EPA). R&D: Map regions of water quality that can meet needs of ethanol production. R&D: Conduct water availability assessment (quantity and quality) to determine viability of oil shale/oil sands production capability and limits		**GOAL: Tracking of secondary water use availability for energy production**
Enhanced data collection of groundwater availability and variability	Limited regional understanding of groundwater availability and future demands and availability	R&D: To determine the volumes of groundwater available for energy production, determine recharge rates/groundwater-surface water interactions and develop calculation methods. R&D: Determine quantity, quality, location of groundwater resources to aid in regional energy planning/siting activities.	T&E: Develop pilot-scale efforts to apply developed approaches to regional energy and water planning	

Data Needs (Non-technology development, non-environmental research)

Topic 1. Establishing Data Standards/Needs
GOAL: On-line, integrated information system and databases geared to providing data for regional and national energy/water modeling and planning.

- o STUDY: Define what types/scale of data are needed for energy/water modeling
  - ▪ Frame questions
  - ▪ Identify data needed for regional or national energy/water planning (including identification of output parameters, accuracy and precision requirements)
  - ▪ Evaluate and assess water data needs for energy
  - ▪ Statistical methods for robust monitoring—where/how frequently to monitor for energy-water planning
- o STUDY: Examine and identify data needs and gaps as a result of defining data needs for energy/water modeling. (USGS, DOE)
- o Coordinate quality/quantity monitoring and data collection matching (temporal, areal scales). (USGS, states, DOE)
- o Mid-Term activity: Develop a remote sensing/GIS based program for rapid access to the output data for regional and national energy planning.
- o Mid-Term activity: Define/deploy standardized data collection framework across fed/state/local entities.

Topic 2. Enhanced data collection/mapping of impaired and brackish water resources
GOAL: Tracking of secondary water use availability for energy production

- o Develop parameters for a national inventory of impaired water resources that may be utilized in/for energy production (DOE/USGS/EPA and others)
- o Evaluation/analysis/quantification/mapping of non-traditional/produced/brackish /reused waters quantity and quality that could be used for energy development
- o Map regions of water quality that can meet needs of ethanol production.
- o Conduct water availability assessment (quantity and quality) to determine viability of oil shale/oil sands production capability and limits

Topic 3. Enhanced data collection of groundwater availability and variability

- o To determine the volumes of groundwater available for energy production, determine recharge rates/groundwater-surface water interactions and develop calculation methods.
- o Determine quantity, quality, location of groundwater resources to aid in regional energy planning/siting activities.
- o Mid-Term activity: Develop pilot-scale efforts to apply developed approaches to regional energy and water planning

ENVIRONMENTAL/ECOLOGICAL/NATURAL PROCESSES RESEARCH

Ecosystem needs/impacts research for hydropower applications	Ecological issues are driving water release considerations and impacting hydro operations	R&D: Improve science foundation of regulations to maximize hydropower generation • Support development of site-specific, science-based water temp/flow variability reqs/stds. (USGS-BRD/FWS/NOAA/DOE) • Improve existing biological tools/models/metrics—mortality vs. pop impacts (compensatory models)(USGS-BRD/DOE) • Establish quantitative links between habitat and fish population yields. R&D: Determine biological effects of kinetic systems (DOE)	T&E: Pilot-testing of advanced systems to reduce ecological impacts	**GOAL: Improve performance of hydro systems with ecological system.**
Evaluate ecosystem water needs and impacts on water availability and energy generation and production	Ecosystem impacts on water availability are not well understood Experience with thermal discharge effects on lg. waterbodies well known; less so regarding discharges to smaller waterbodies / rivers which experience drought-induced low flow conditions	R&D: As related to energy-specific impacts of withdrawals/discharges, identify the minimum and maximum flows and water quality parameters needed to maintain a stream quality index at a desired level for hydro-thermal- power. (USGS/BRD, DOE, EPA, FWS) R&D: Develop a set of criteria/system that define the status of an aquatic ecosystem taking into account community health, reach dimensions and ecosystem services to assess energy development options. R&D: Examine cases other than discharges into lg. waterbodies; conduct impacts studies on those.	R&D: Identify the sensitivity of aquatic organisms, fish populations, and other ecologic health on the interaction between water flow, water quality, flow timing, etc related to (DOE, USGS/BRD, EPA, FWS) R&D: Assess river management approaches to increase plant efficiency (cold water reservoirs)	R&D: Develop species/ aquatic community specific responses. (DOE/USGS/others) **GOAL: Consistent science-based approach for ecological water needs evaluations relative to energy development**
	Ecological effects are generally descriptive or quantified in a way that does not permit site to site comparison or translation into remediation or utilization benefits or costs. Existing USBS / USFWS work in characterizing habitat limited to minimum flow issues associated with FERC	R&D: Define ecosystem needs/research biological response wrt produced water (USGS/BRD, DOE, EPA, FWS) • Establish ranges of water qualities that must be met by newly-developed produced water treatment technologies (USDA, USGS/BRD, DOE, FWS, EPA) R&D: Develop a set of criteria/system that define the status of an aquatic ecosystem taking into account community health, reach dimensions and ecosystem services. Utilize as benchmark for assessing produced water impacts. R&D: Assess impacts of increased flow of produced water on river environments and ground water as a result of produced water discharge (BLM, State departments of environmental quality or similar, DOE) R&D: Evaluate/model potential groundwater contamination as a result of oil shale/oil sands extraction and processing. R&D: Evaluate fate of post-use water (oil shale/oil sand extraction).	T&E: Standardize collection of water evaluation and biological response information and data R&D: Develop improved models of aquifer impacts from CBNG production/surface discharge T&E: Verify the developed ecological system analysis approach in major regions across the country and adapt to local conditions.	**GOAL: Establish produced water discharge requirements to meet science-based ecological values and needs**

Environmental/Ecological/Natural Processes Research

Topic 1. **Ecosystem needs/impacts research for hydropower applications**
GOAL: Improve performance of hydro systems with ecological system.

- o Improve science foundation of regulations to maximize hydropower generation
    - ▪ Support development of site-specific, science-based water temp/flow variability reqs/stds.
    - ▪ Improve existing biological tools/models/metrics—mortality vs. pop impacts (compensatory models)
    - ▪ Establish quantitative links between habitat and fish population yields.
- o Determine biological effects of kinetic hydropower systems
- o Mid-Term activity: Pilot-testing of advanced systems to reduce ecological impacts

Topic 2. Evaluate ecosystem water needs and impacts on water availability and energy generation and production
GOAL: Consistent science-based approach for ecological water needs evaluations relative to energy development

- o As related to energy-specific impacts of withdrawals/discharges, identify the minimum and maximum flows and water quality parameters needed to maintain a stream quality index at a desired level for hydro-thermal- power.
- o Develop a set of criteria/system that define the status of an aquatic ecosystem taking into account community health, reach dimensions and ecosystem services to assess energy development options.
- o Examine cases other than discharges into large waterbodies; conduct impacts studies on those.
- o Research uncertainty in linkages (air emissions from power plants to pollutant levels in aquatic ecosystems. Biogeochemical cycling. Marine source?
- o ==Ecological studies of fresh/seawater intakes on ecosystem quality==
- o Mid-Term activity: Identify the sensitivity of aquatic organisms, fish populations, and other ecologic health on the interaction between water flow, water quality, flow timing, etc.
- o Mid-Term activity: Assess river management approaches to increase plant efficiency (cold water reservoirs)
- o Long-Term activity: Develop models of species/aquatic community-specific responses.

Topic 3. Ecological impacts of produced waters
GOAL: Establish produced water discharge requirements to meet science-based ecological values and needs

- o Research biological response with respect to produced water
    - ▪ Assess impacts of increased flow of produced water on river environments and ground water as a result of produced water discharge
    - ▪ Establish ranges of water qualities that must be met by newly-developed produced water treatment technologies

- Develop a set of criteria/system that define the status of an aquatic ecosystem taking into account community health, reach dimensions and ecosystem services. Utilize as benchmark for assessing produced water impacts.
- Mid-Term activity: Standardize collection of water evaluation and biological response information and data
- Mid-Term activity: Develop improved models of aquifer impacts from coal bed natural gas production/surface discharge
- Mid-Term activity: Verify the developed ecological system analysis approach in major regions across the country and adapt to local conditions.

Topic 4. Impacts of Oil Shale/Oil Sand Extraction and Processing

- Evaluate/model potential groundwater contamination as a result of oil shale/oil sands extraction and processing.
- Evaluate fate of post-use water.

DATA COLLECTION TECHNOLOGIES

| Improved water monitoring technologies | $5k per hole for gw monitoring/ assessment

$10k/station/year for surface water monitoring

Better snow pack monitoring

Low-cost data collection for remote high altitude water sensing | R&D: Develop enhanced monitoring technologies to
• Plug-n-play communication systems for provision of real-time water quality/quantity data for energy facilities—cellular (80% of costs in communications)
• Soil moisture monitoring/reporting systems for water conservation in agricultural sector
• More accurately measure snow pack and water content at high altitudes to better predict water availability for hydro and thermoelectric energy
T&E: Apply on a regional/watershed scale the Wisconsin approach to real-time monitoring/reporting of water availability for energy generation | T&E: Establish field sites for validation of technologies and approaches and | **GOAL: Reduce costs of Real time, on-line flow and quality data availability to support energy planning and development**

GOAL: Reduce monitoring costs by 75%

GOAL: Water yields by watershed would be available for all users as is currently the case for USGS gauging stations in some states |
| | | R&D: Develop additional data collection technologies to validate watershed and regional scale climate models and better gauge seasonal water supply
• Develop advanced remote sensors for model validation
• Include high elevation climatic monitoring stations to better evaluate snowpack | | |

Data Collection Technologies

Topic 1. Improved water monitoring technologies
GOAL: Water yields by watershed would be available for all users as is currently the case for USGS gauging stations in some states
GOAL: Reduce costs of Real time, on-line flow and quality data availability to support energy planning and development
GOAL: Reduce monitoring costs by 75%

- o Develop enhanced monitoring technologies
  - ▪ Plug-n-play communication systems for provision of real-time water quality/quantity data for energy facilities
  - ▪ Soil moisture monitoring/reporting systems for water conservation in agricultural sector
- o Apply on a regional/watershed scale the Wisconsin approach to real-time monitoring/reporting of water availability for energy generation
- o Mid-Term activity: Establish field sites for validation of technologies and approaches
- o Develop data collection technologies to validate watershed and regional scale climate models and better gauge seasonal water supply
  - ▪ Develop advanced remote sensors for model validation
  - ▪ Include high elevation climatic monitoring stations to better evaluate snowpack and water content at high altitudes

MODEL CREATION

Water Variability—Modeling Climate Change Impacts	While reasonable global climate models exist, there is a lack of ability to do climate and water variability forecasting at the regional level Climate model predictions are currently too coarse for meaningful analysis ; predictions of short-falls in precipitation vs areas that may benefit from shifts in precipitation patterns.	R&D: To predict water available for energy facilities, develop regional/watershed scale models with stream flow and groundwater as dependent variables and landscape, climate, geology, vegetation, evapotranspiration as independent variables. Models will provide insight into major regional water availability issues and drivers. (NOAA/DOE)	T&E: Establish field sites to collect climate data and validate models against field data using DOE/ARM program approach as model. (DOE) T&E: Validate watershed climate models, perhaps using the Atmospheric Radiation Monitoring program as a model (DOE)	**GOAL: Develop approaches to provide insight into major regional drivers on water variability and impacts on energy generation**
		R&D: Develop approaches to run regional climate models more efficiently using parallel computing. (DOE/NOAA)		
		R&D: Commence precipitation pattern detection research	**GOAL: Finer resolution of changes in precipitation patterns resulting from climate changes.**	**GOAL: Quantitative links between changes in precipitation patterns and watershed yields for surface waters.**
Integrating energy and water models	Lack of approach to collect water data to improve energy planning	R&D: Create interfaces between energy and water planning models (DOE/USGS) T&E: Identify the 4 or 5 most important parameters in energy/water planning models to focus data collection efforts (DOE/USGS) T&E: Couple power needs forecasts, incl. type of generation with requisite water demands, with forecasts of water availability within regions of concern. R&D: Model climate variability impacts on generation technologies and energy needs		**GOAL: Provide data needed for decision models and regional cooperative energy-water resource planning**

Topic 1. Climate Change Impacts on Water Variability
GOAL: Develop approaches to provide insight into major regional drivers on water variability and impacts on energy generation
GOAL: Finer resolution of changes in precipitation patterns resulting from climate changes
GOAL: Quantitative links between changes in precipitation patterns and watershed yields for surface waters.

- o To predict water available for energy facilities and to provide insight into major regional water availability issues and drivers, develop regional/watershed scale models with the following characteristics
    - ▪ Dependent variables: Stream flow and groundwater
    - ▪ Independent variables: Landscape, climate, geology, vegetation, evapotranspiration as independent variables.
- o Develop approaches to run regional climate models more efficiently using parallel computing.
- o Commence precipitation pattern detection research
- o Mid-Term activity: Establish field sites to collect climate data and validate models against field data using DOE/ARM program approach as model.
- o Mid-Term activity: Validate watershed climate models, perhaps using the Atmospheric Radiation Monitoring program as a model

Topic 2. Integrating energy and water models
GOAL: Provide data needed for decision models and regional cooperative energy-water resource planning
- o Create interfaces between energy and water planning models
- o STUDY: Identify the 4 or 5 most important parameters in energy/water planning models to focus data collection efforts
- o Couple power needs forecasts, incl. type of generation with requisite water demands, with forecasts of water availability within regions of concern.
- o Model climate variability impacts on generation technologies and energy needs